Before closing I must refer to the comparative lengths of exposure required for these photographs. My impression is that at A the exposure required is about 25 times that required for G, in a fairly bright sun at midday; for the ultra red, as far as I have gone, I should say about 35 times. These are only approximations, but still will enable you to form some idea of the sensitiveness. I show you a photograph taken about 4 P.M. on March 18. The exposure was about 50 seconds. You will see that the red end is as strong as the blue, with the yellow much lacking in density. In other words, the yellow rays are nearly inactive.

The photograph which I showed you of the four orders of the spectrum was taken on April 3, at 2.30. It had an exposure of one minute and a half. The photograph in which the furthest band of lines was seen had an exposure of 12 minutes on the 8th, at 2.30. The slit was in this case closed as nearly as possible.

In conclusion, I have to remark that in a short time I hope to reduce the exposures considerably. In the course of some investigations, the results of which have just been communicated to the Royal Society, I found that the red rays could oxidise a photographic image as well as form it, and that in an oxidised state it was unable to be developed. If the tendency of the sensitive compound to become oxidised exceeded its tendency to become reduced, no image could be developed. By exposing *in vacuo* or in a nitrogen atmosphere I hope to eliminate altogether this oxidising effect, and so get firmer images.

I trust that this paper may be considered as the fulfilment of the promise implied in my preliminary note.

On the Duration of Meteor Showers. By R. P. Greg, Esq.

In the No. of the *Monthly Notices* of the Society for January 1878, Mr. Denning has a paper on "Suspected Secondary or Repetitive Outbursts from Radiant-points; and on the long Duration of Meteor Showers"; and Captain Tupman has appended some valuable remarks on Mr. Denning's paper.

1. In the case of a *second* outburst of the same supposed meteoric radiant, some two, three, or even four months after the first (supposing it to be a true case of double intersection of the same meteor orbit, say near its perihelion), then I imagine it could easily be shown that the apparent positions of the radiant, on each occasion, must necessarily lie at least in different quarters of the heavens; and it would be an almost impossible matter to decide whether the two radiants belonged to one and the same shower and orbit; unless indeed the individual meteors were wonderfully characteristic and similar in appearance.

2. With respect to the *duration* of meteor showers, though I

think Mr. Denning may rather exaggerate that element, my own experience would certainly favour the idea of a longer average duration for meteor showers having a very fairly decided fixed radiant than one could have supposed likely. In *not* a few cases the duration would even seem to endure for two or three months without any special intermission. But leaving out such extreme cases, as caused probably by two distinct showers overlapping each other as it were, let us consider the *average* duration of meteor showers, so far as can be judged from some of the principal Catalogues. In the late Professor Heis' latest Catalogue (1877) there are specified no less than 120 different meteor showers with their radiant positions for the six months July to December. The *average* duration I find for each is $20\frac{1}{2}$ days and the number of meteors recorded about 6,000, without any undue allowance for *Perseids* and *Leonids*, and there are 14 showers lasting over 34 days. The observations extend over a period of 25 years.

The average duration of 105 showers, 2,300 meteors, as deduced from Mr. Denning's reductions of the Italian observations, 1872, July–December, is 24 days. Mr. Denning's own observations, reduced from 2,170 meteors in 1876–7, give an average of 22 days.

In Dr. Schmidt's Catalogue there are 45 meteor showers with duration of about 30 days or more. In my own Catalogue, reduced from 2,000 meteors seen in England 1849–1867, the average duration for 40 showers for the whole year is 33 days (omitting 12 showers over 54 days, some of which are doubtless not really one shower).

I think we may therefore take it for granted, until at least proved to be incorrect, that the *average duration* of a meteor shower having a pretty constantly fixed radiant area, say of from 3°–8° in diameter, is not less than *three weeks*. Now, as some of these meteor showers only endure for *one* or *two* days, it is not unreasonable to assume for a *maximum* a duration of even *six weeks*; that is to say, meteor showers, so far as ascertained, endure from one to at least 40 days, giving in most cases a pretty fixed radiant in the heavens. There are not an inconsiderable number of cases in which the duration would appear to be even as great as 50 or 60 days, but this would appear to be so surprising that further proof and long continued nightly watching and recording is requisite to confirm it. The *Perseids* belong to a shower having a strong *maximum*, as is well known, about August 10, but it is perhaps not equally well known that this shower feebly commences about July 24 and continues until about August 17, ending much more suddenly than it commences.

The *Leonids* last for a few days with a strong maximum of only a few hours; the *Andromedids* for not more than half-a-day.

When, as we have shown, it may appear highly probable that the *average* duration of a meteor shower (of which at least 200 are now known whose orbits are intersected by the Earth) is

about *three weeks*, it must stand to reason that a considerable number may be expected to show a duration of at least five or six weeks, if not very occasionally more.

Captain Tupman has clearly pointed out the special conditions required to produce a nearly fixed meteor radiant for several weeks, viz. "The meteor orbit must nearly coincide with the plane of the ecliptic, the perihelion distance of the central position be a little less than unity, and the motion direct. The position would be 90° before the Sun at the middle time."

I am inclined, however, to think that another reason, which may assist in explaining the apparent difficulty of a rather frequent *long* duration with fixity of radiant, may be found in the supposition that the zone or ring of meteors belonging to a majority of showers may be a good deal wider or more diffuse than hitherto supposed, possessing a width in fact of several millions of miles, and this at the same time not improbably coincident with a considerable degree of parallelism in the direction of the orbits of the Earth and meteors at the time.

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*On the Solution by Trial of Lambert's Theorem, in Olbers' Method for the Computation of Parabolic Orbits.** By R. H. M. Bosanquet, Fellow of St. John's College, Oxford.

In all the different forms of the method of Olbers for the computation of parabolic orbits there is a certain step, depending in principle on the finding by trial of values of the heliocentric radii vectores of the comet which satisfy the condition given by the application of Lambert's Theorem to the observed times.

In the Appendix to Olbers' treatise, at pp. 68–71 of Encke's edition (1864), a method is given by which, from any assumption as to the value of the chord joining the first and third places of the comet, or of the sum of the corresponding geocentric radii vectores, more accurate values can be deduced by Lambert's theorem. This discussion contains the germs of the principal subsequent improvements of the method; and the form given to Lambert's theorem in the Note (Encke's *Olbers*, p. 70) is that on which the present discussion will be based.

In the Gaussian modification of Olbers' method, a plan is commonly adopted which is in principle the same as that recommended by Olbers in the place cited. It consists in assuming a value of u, for which Encke has given the formula

$$\left\{\left(\frac{t''-t}{41}\right)^2 - A^2\right\}^{\frac{1}{2}},$$

* A paper on this subject was written by the author some years ago, and appeared in the *Astronomische Nachrichten* in 1872. On reading it over the author thinks that the method may still be worth the attention of the Society. The investigation is substantially unaltered, but the discussion of the example has been revised.